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TITLE: NAVIGATION SYSTEM THAT
SUPPORTS MULTIPLE
LANGUAGES AND FORMATS

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1 NAVIGATION SYSTEM THAT SUPPORTS
2 MULTIPLE LANGUAGES AND FORMATS

3 BACKGROUND OF THE INVENTION

4 The present invention relates to a navigation system, and more particularly, the
5 present invention relates to a navigation system that includes a centrally-located server
6 that provides language- and format-independent navigation-related information to one or
7 more other servers, which in turn use the language- and format-independent navigation-
8 related information to formulate specific navigation instructions which are provided to
9 end users.

10 Navigation systems provide various useful features, such as calculating routes to
11 desired destinations, providing guidance for following calculated routes, displaying maps,
12 and so on. There are various computer architectures for navigation systems that deliver
13 navigation-related features. In one type of architecture for a navigation system, end users
14 use electronic devices to obtain navigation information from a remotely located server.
15 The end users electronic devices may include general purpose devices, such as cell
16 phones, personal digital assistants (PDAs), personal computers (desktop and portable), as
17 well as special purpose devices, such as specially designed navigation system units.
18 These end users' devices are used to send requests for navigation-related information
19 over a communications network to the remotely located server. The communications
20 network may include the Internet or any other type of communications medium. When
21 the remotely located server receives a request for navigation information from an end
22 user's device, it uses navigation application software programs and geographic data
23 contained in one or more databases to determine a response to the request and then sends
24 the response to the end user over the communications medium. An example of this type
25 of navigation system is disclosed in U.S. Pat. No. 5,543,789, the entire disclosure of
26 which is incorporated by reference herein.

27 This type of navigation system architecture provides several advantages. One
28 advantage relates to providing updated geographic data. There is a continuing need to

1 update the geographic data used by a navigation system. For example, new streets are
2 built, road construction closes roads, detours are established, new businesses open, posted
3 speed limits change, new turn restrictions are established at intersections, streets are
4 renamed, and so on. These kinds of changes can affect travel through a geographic
5 region. Accordingly, the geographic data used by a navigation system should be updated
6 on a regular basis in order to accurately reflect changes in the represented geographic
7 features. A computer architecture in which end users obtain navigation-related services
8 from a single central server affords an advantage with respect to the updating of the
9 geographic data. With a computer architecture in which end users obtain navigation-
10 related services from a central server, updates need to be applied only to the geographic
11 database(s) associated with the central server.

12 Although there are advantages associated with a navigation system architecture in
13 which end users obtain navigation services from a central server, there are considerations
14 that need to be addressed. One consideration relates to providing navigation-related
15 information in a variety of different languages. As an example, some end users may want
16 navigation information in English, whereas other end users may want navigation
17 information in French, Spanish, or another language. Another consideration relates to
18 providing navigation-related information for a variety of formats. As an example, some
19 end users may have systems that support graphical images of maps that illustrate the
20 navigation-related information, whereas other end users may have systems that support
21 only text instructions. It would be preferable that a navigation server support various
22 different languages and various different types of end user systems. However, this can be
23 difficult to accomplish because of the relatively large number of different types of end
24 user systems, as well as the number of different languages. Thus, there is a need for an
25 improvement that facilitates the provision of navigation-related information to different
26 kinds of end user computing platforms and in different languages.

27

28 SUMMARY OF THE INVENTION

29 To address these and other objectives, the present invention comprises a system
30 and method that includes a navigation-related information server that provides
31 navigation-related information in a language- and format independent format. The

1 navigation-related information server responds to requests for navigation-related
2 information from one or more customer-interface servers. Each customer-interface
3 server receives requests for navigation-related information from end users that have end
4 user computing platforms. The end users send their requests for navigation-related
5 information from end user computing platforms over a data network to the customer-
6 interface servers. In order to respond to the end users, the customer-interface servers
7 request language and format-independent navigation-related information from the
8 navigation-related information server. The navigation-related information server receives
9 the requests from the customer-interface servers. To respond to each request for
10 navigation-related information, the navigation-related information server uses one or
11 more geographic databases to formulate language- and format-independent data
12 structures. These language- and format-independent data structures are sent to the
13 customer-interface servers. The customer-interface servers receive the language- and
14 format-independent responses from the navigation-related information server and
15 formulate language- and format-specific responses that are sent to the end users.

16 In one embodiment, the language and format-independent data structures
17 provided by the navigation-related information server are in XML format. The customer-
18 interface servers use XML style sheets to formulate language and format-specific
19 responses that are sent to the end users.

20 BRIEF DESCRIPTION OF THE DRAWINGS

21 Figure 1 is a block diagram illustrating components of an embodiment of a
22 navigation system that provides navigation services to end users' computing devices
23 located throughout a geographic region.

24 Figure 2 is a block diagram showing components of the navigation-related
25 information provider and customer-interface provider in Figure 1.

26 Figure 3 is a block diagram illustrating components of the navigation applications
27 installed on the navigation-related information server of Figures 1 and 2.

28 Figure 4 is a diagram illustrating the components of the route calculation object of
29 Figure 3.
30

Figure 5 is a diagram illustrating the components of the maneuver generation application of Figure 3.

Figure 6 is a diagram illustrating the component members of one of the maneuver data structures of Figure 5.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

I. OVERVIEW OF NAVIGATION SYSTEM

Figure 1 shows a geographic region 100. The geographic region 100 may correspond to a metropolitan or rural area, a state, a country, or combinations thereof, or any other area of comparable size. Located in the geographic region 100 is a road network 104.

A navigation system 110 serves end users (e.g., vehicle drivers and passengers, as well as other persons and businesses) in the geographic region 100. The navigation system 110 is used by the end users to obtain navigation-related services. The navigation-related services include information about travel along the road network 104, including route calculation and guidance. The navigation-related services may also include people and business finding services (e.g., electronic yellow and white pages), map display, point of interest searching, destination selection, and so on.

The navigation system 110 is a combination of hardware, software and data. The navigation system 110 includes remote components, i.e., hardware, software or data located remotely from the end users, and local components, i.e., hardware and/or software located physically with each end user.

The local components of the navigation system 110 include the various electronic devices and computer platforms 130 operated by end users to request and obtain navigation-related services using the navigation system 110. These various end user computer platforms (also referred to as “end user electronic devices” or “client computing platforms” or the like) may include general purpose devices, such as cell phones, personal digital assistants (PDAs, PalmPilot®-type devices), personal computers (desktop and portable), as well as special purpose devices, such as specially designed navigation system units located in vehicles 134.

The end user devices 130 have the appropriate hardware and software to transmit and receive data over a data network 140. The data network 140 may use any suitable technology and/or protocols that are currently available, as well as technology and/or protocols that become available in the future. For example, the data network 140 may use WAP, TCP/IP, i-mode, etc. More than one protocol may be used in the data network 140 with appropriate conversions. The data network 140 may include the Internet.

The data network 140 may include a wireless portion 142. The wireless portion 142 may be implemented by any suitable form of wireless communication, including cellular, PCS, satellite, FM, radio, or technologies that may be developed in the future. The wireless portion 142 may include one or more transmitters 144, such as a transponder tower, an antenna tower, an FM tower, satellites, or other suitable means. The transmitters 144 include an appropriate communication link 146 to the network 140. This link 146 may be land-based or may be wireless. The transmitters 144 include suitable technology that enables two-way communication with the mobile end user computing platforms 130.

II. THE NAVIGATION-RELATED INFORMATION SERVER AND THE CUSTOMER-INTERFACE SERVER

The remote components of the navigation system 110 include a navigation-related information server 200 and one or more customer-interface servers 202(1), 202(2) Figure 2 is a block diagram showing some of the components of the navigation-related information server 200 and one of the customer-interface servers 202(1). (The customer-interface server 202(1) is representative of all the other customer-interface servers, which may have similar or identical components.)

A. The customer-interface server 202(1)

The customer-interface server 202(1) is maintained and operated by a customer-interface provider 220.

The customer-interface server 202 includes a communications system 222. The communications system 222 interfaces with the data network 140. The communications system 222 has the appropriate hardware and software to receive messages from and send messages to the end user electronic devices 130 over the data network 140. The

1 communications system 222 is also capable of receiving messages from and sending
2 messages to the navigation-related information server 200. In one embodiment, the
3 network used by the customer-interface server 202(1) to communicate with the
4 navigation-related server 200 is the same data network (i.e., network 140) used to
5 communicate with the end user electronic devices 130.

6 Included on the customer-interface server 202(1) are customer-interface
7 applications 230. One of the customer-interface applications 230 is a subscriber services
8 application 234. In order to use some or all of the services provided by the customer-
9 interface provider 220, end users may be required to be subscribers. The subscriber
10 services application 234 provides services that support this function. Some of the
11 subscriber services include enrollment, payments, renewals, confirmation of subscriber
12 status, targeted advertising, and so on. The subscriber services application 234 may use a
13 subscriber database 235 that contains various kinds of information concerning the various
14 subscribers.

15 Also included among the customer-interface applications 230 on the customer-
16 interface server 202(1) are data conversion applications 240. The data conversion
17 applications 240 receive the messages requesting navigation-related services from the end
18 users devices 130, extract pertinent content regarding the type of navigation-related
19 information desired by the end users, and formulate requests to send to the navigation-
20 related information server 200 for the navigation-related data needed to response to the
21 end user requests. The data conversion applications 240 also receive data messages
22 containing navigation-related data from the navigation-related information server 200,
23 extract the navigation-related information from the messages received from the
24 navigation-related information server 200, formulate meaningful language- and format-
25 specific navigation guidance or other information for the end users, and transmit the
26 meaningful language- and format-specific guidance or other information to the end user
27 computing platforms 130. The data conversion applications 240 are described in more
28 detail below.

29

1 B. The navigation-related information server

2 The navigation-related information server 200 is maintained and operated by a
3 navigation-related information provider 260.

4 The navigation-related information server 200 includes a communications system
5 266. The communications system 266 interfaces with the data network 140. The
6 communications system 266 associated with the navigation-related information server
7 200 has the appropriate hardware and software to receive messages from and send
8 messages to customer-interface server 202(1), as well as the other customer-interface
9 servers 202(2) . . . over a data network, which in one embodiment is the data network
10 140.

11 Associated with the navigation-related information server 200 are one more
12 geographic databases 270. The geographic databases 270 are stored on media which may
13 be located with the navigation-services server 200. Various storage media may be used,
14 including fixed or hard disks, DVD disks or other currently available storage media, as
15 well as storage media that may be developed in the future.

16 The geographic databases 270 include information about the roads and
17 intersections in or related to one or more geographic regions or coverage areas (such as
18 the geographic region 100 in Figure 1). This information includes data specifying the
19 positions of the roads in the covered geographic region and also includes data about
20 features relating to the roads, such as restrictions on directions of travel on the roads (e.g.,
21 one-way streets), turn restrictions, street addresses, street names, speed limits, and so on.
22 The geographic databases 270 may also include information about points of interest in
23 the geographic areas, such as hotels, restaurants, museums, stadiums, offices, automobile
24 dealerships, auto repair shops, etc. The geographic databases 270 may also include
25 information about places, such as cities, towns, or other communities. The geographic
26 database 270 may include other data about the geographic region.

27 In one embodiment, the geographic databases 270 and the data contained therein
28 are provided by Navigation Technologies Corporation of Chicago, Illinois. However, it
29 is understood that databases developed and provided by other entities may also be
30 suitable for use with some of the embodiments disclosed herein.

1 The geographic databases 270 may take a variety of different forms and/or
2 formats. The geographic databases may be organized in one or more formats in order to
3 facilitate the provision of various navigation-related information and functions. Methods
4 of organizing a geographic database to enhance the performance of certain navigation-
5 related functions are described in U.S. Pat. Nos. 5,974,419, 5,968,109 and 5,953,722, the
6 entire disclosures of which are incorporated by reference herein.

7 One format that may be used for organizing the geographic databases 270 is the
8 SDAL® format provided by Navigation Technologies Corporation. The present
9 embodiments are not limited to any particular format and other formats may be used.

11 III. THE NAVIGATION APPLICATIONS

12 Associated with the navigation-related information server 200 are navigation
13 applications 280. The navigation applications 280 may be formed of separate component
14 applications (also referred to as programs, subprograms, routines, or tools). The
15 navigation applications 280 work together through defined programming interfaces. The
16 navigation applications 280 use the geographic databases 270 associated with the
17 navigation-related information server 200 in order to provide the various different types
18 of navigation-related information.

19 Figure 3 shows some of the navigation-related applications 280 on the navigation-
20 related information server 200. In addition to the applications shown in Figure 3, the
21 navigation-related information server 200 may include other navigation applications.

22 The navigation applications 280 are programs that provide for specific navigation
23 functions to be performed by the navigation-related information server 200. In the
24 embodiment of Figure 3, the navigation applications 280 request and obtain data from the
25 geographic database 270 and use the data to satisfy the requests for navigation
26 information from the customer-interface servers 202(1), 202(2) The navigation
27 applications 280 may obtain the geographic data directly from the geographic database
28 270, or alternatively, the navigation applications 280 may obtain the data through an
29 interface layer 284 and an operating system 286.

30 As shown in Figure 3, the navigation applications 280 include a manager
31 application 288. The manager application 288 is a program or routine that provides for

1 an overall interface to the navigation applications on the navigation-related information
2 server 200.

3 Among the navigation applications 280 on the navigation-related information
4 server 200 is a route calculation application 290. In the embodiment of Figure 3, the
5 route calculation application 290 receives its input from the navigation manager 288.
6 The route calculation application 290 receives input in the form of data that identify at
7 least an origin and a desired destination. The route calculation application 290 may also
8 receive additional input information that affects the calculation of the route. For
9 example, the additional input to the route calculation application 290 may include data
10 that specify user preferences such as avoidance of toll roads or expressways, and so on.
11 The input may also include data that identifies the time of day at which the route will be
12 started which may affect the route calculation.

13 Given data that identify the positions of an origin and destination, the route
14 calculation application 290 uses data from the geographic databases 270 to calculate a
15 route between the origin and the destination. The route calculation application 290 may
16 use any of various means or algorithms for this purpose. For example, the route
17 calculation application 290 may use either the A* algorithm or the Dykstra algorithm.
18 Alternatively, the route calculation application 290 may use the methods for calculating
19 routes disclosed in U.S. Pat. No. 6,192,314, the entire disclosure of which is incorporated
20 by reference herein. The methods disclosed in U.S. Pat. No. 6,192,314 represent only
21 some of the ways that routes can be calculated and the claimed subject matter herein is
22 not limited to any particular method of route calculation. Any suitable route calculation
23 method now known or developed in the future may be employed.

24 Regardless of the method used, the route calculation application 290 provides an
25 output in the form of a list identifying a continuous series of roads (or segments thereof)
26 that form a legally valid solution route between an origin and a destination. A “legally
27 valid solution route” conforms to known traffic restrictions, such as one way streets, turn
28 restrictions, etc. The method used by the route calculation application 290 may be
29 designed to optimize the solution route to meet one or more predetermined criteria. Such
30 criteria may include the least travel time, the shortest distance, the fewest turns, etc. If
31 the method used by the route calculation application 290 is designed to find a solution

1 route that is optimized for one or more criteria, then the solution route also ideally meets
2 these one or more criteria.

3 In the embodiment of Figure 3, the output of the route calculation application 290
4 is in form of a route calculation object 302. Figure 4 is a diagram representing the
5 components of the route calculation object 302. The route calculation object 302
6 contains an ordered list 304 identifying a plurality of road segment data entities (i.e.,
7 *seg1, seg2, seg3 . . . seg(n)*). The plurality of data entities represent the road segments
8 that form the continuous navigable route between the origin and the destination that had
9 been calculated by the route calculation application 290. Since these segments form a
10 continuous route, each segment shares a node with its successor segment in the list. For
11 example, as shown in Figure 4, the segments “*seg2*” and “*seg3*” are shown to have a
12 common node “*N3*.” The route calculation object 302 may include other information
13 306 in addition to the ordered list of road segment data entities.

14 Referring to Figure 3, the route calculation object 302, which is created by the
15 route calculation application 290, is used as an input to the route guidance application
16 310. (The route guidance application 310 is another of the navigation applications 280.)
17 The route guidance application 310 is comprised of a maneuver generation application
18 320. The maneuver generation application 320 uses as its input the route calculation
19 object 302 formed by the route calculation application 290. (Methods for providing the
20 functions performed by the maneuver generation application 320 are disclosed in U.S.
21 Pat. No. 6,199,013, the entire disclosure of which is incorporated by reference herein.
22 The maneuver generation application 320 describe herein is similar to the subject matter
23 disclosed in the referenced patent.)

24 The maneuver generation application 320 performs at least two functions. The
25 maneuver generation application 320 uses the information in the ordered list 304 of
26 segment data entities in the route calculation object 302 to determine which locations
27 along the calculated route should be explicated to the end user with a maneuvering or
28 advisory instruction. In addition, for each of the locations determined as requiring
29 explication, the maneuver generation application 320 collects information needed to
30 provide a maneuvering or advisory instruction for the particular location.

1 In performing these functions, the maneuver generation application 320 uses two
 2 objects. Referring to Figure 5, the maneuver generation application 320 includes a
 3 (maneuver generation) configuration object 330 and maneuver generation object 340.
 4 The (maneuver generation) configuration object 330 contains maneuver rules 332. These
 5 maneuver rules 332 are applied using the data in the route calculation object 302 and
 6 from the geographic database 270. These rules determine when a location along the
 7 calculated route should be explicated with a maneuvering instruction. As mentioned
 8 above, the route calculation object 302 contains the list 304 of data entities that represent
 9 segments of roads. Because this list represents road segments that form a continuous
 10 route, each road segment represented by a data entity in the list 304 shares a node (i.e., an
 11 “endpoint”) with a road segment represented by an adjacent data entity in the list. The
 12 maneuver rules 332 are applied at each of these nodes in the list 304.

13 In applying the maneuver rules 332, the direction of travel of the calculated route
 14 is taken into account. Thus, the segment by which the calculated route leads into the
 15 node being tested by the maneuver rules 332 is identified as the entry segment. The
 16 segment by which the calculated route leads out of the node being tested by the maneuver
 17 rules 332 is identified as the exit segment. In addition, all the other road segments that
 18 are not part of the calculated route, but that share this same node with the entry and exit
 19 segments are identified. The data entities that represent all these road segments are
 20 obtained from the database 270.

21 The maneuver rules 332 are provided in the form of a table 333. The table 333
 22 defines a plurality of maneuver types 334 and a plurality of maneuver condition tests 335.
 23 Each of these maneuver types 334 characterizes a particular kind of roadway
 24 configuration change that can occur at the node being tested from the calculated route.
 25 Each maneuver type 334 is assigned a unique code or number.

26 Each of the maneuver condition tests 335 is formulated to accept only a positive
 27 or negative answer. Each maneuver type 334 defined in the table 333 is associated with a
 28 unique subset of the plurality of maneuver condition tests 335. Each maneuver condition
 29 test 335 uses the data in the data entities which had been obtained from the database 270
 30 (such as the data associated with the entry segment, the exit segment, the accessible and
 31 inaccessible segments, and so on) to ascertain whether the condition specified in the

1 maneuver condition test is satisfied. For each node in the calculated route 304, if all the
 2 maneuver condition tests associated with a maneuver type 334 are satisfied, a maneuver
 3 instruction is required for that the node location.

4 For each of the locations determined by the maneuver generation application 320
 5 to require explication, the maneuver generation application 320 forms a maneuver data
 6 structure 350 and adds the maneuver data structure to the maneuver generation object
 7 340. Each maneuver data structure 350 formed by the maneuver generation application
 8 320 contains the information needed to provide a maneuvering instruction to the end user
 9 at the location along the route at which explication has been determined to be provided to
 10 the end user. Some of the data required for the maneuver data structure is included in or
 11 derived from the segment data entities that were tested to determine whether a
 12 maneuvering instruction is required at the location of the node. Additional data may be
 13 required to be obtained or derived from the database 270 by the maneuver generation
 14 configuration object.

15 Figure 6 shows the kinds of data contained in each maneuver data structure 350.
 16 In one embodiment, the maneuver data structure 350 is formed as a C data structure.
 17 Using data from the segment data entities that share the node associated with the
 18 maneuver, as well as any additional data needed or derived from the geographic database,
 19 the maneuver generation object 340 collects data corresponding to the various members
 20 of the maneuver data structure 350. Data are collected to the extent they are available.
 21 Members of the data structure may be left empty if there is no data available (e.g., if one
 22 of the roads at a maneuver location is unnamed).

23 Included in the data structure 350 is a field 350(1)(1) that identifies the number of
 24 segments that meet at the node. The entry and exit segments 350(1)(2), 350(1)(3) into
 25 the node are identified. For each of the segments (entry and exit), the data structure 350
 26 provides for identifying the name(s) of the segment (if any) 350(2)(2), sign(s) on the
 27 segment (if any) 350(2)(3), the rank of the segment 350(2)(4), the segment classification
 28 relative to the entry segment (exit, accessible, inaccessible) 350(2)(5), the database
 29 classification of the segment (e.g., controlled access, street, ramp) 350(2)(6), and the
 30 angle of the segment relative to the entry segment 350(2)(8). In addition, the data
 31 structure 350 also includes a field that can be used to identify the maneuver type (as

described above) 350(4)(2), the distance to the next maneuver 350(4)(4), and whether the maneuver is included in a multiple maneuver 350(4)(1). (A multiple maneuver may be defined by the maneuver generator object when a location at which a maneuvering instruction is determined to be required is so close to an another adjacent location at which a maneuvering instruction is determined to be required that it may be preferable to present the two, or more, maneuver instructions to the end-user at the same time. The distance at which a multiple maneuver is defined is configurable and may be a function of various factors, including speed limits along the road segments, distance, rank, and so on.)

The data structure may also include fields for providing context information 350(3) for the exit road. This kind of information may be useful when the other information in the maneuver structure is not sufficient to describe the exit fully, such as when the exit segment is unnamed. The fields for context information may include a destination string 350(3)(1) which describes the exit of the maneuver in cases where the exit segment name is not sufficient (such as when it is unnamed). The context information 350(3) may also include a field for a "location" 350(3)(2) which gives the location of the exit relative to another road (e.g., before, after, ahead, behind, on the right, or on the left). The context information 350(3) may also include a field for a "turn angle" 350(3)(3) which gives the angle to be taken to go onto the exit road. The context information may also include a field for a "heading" 350(3)(5) which can be used during the starting-off maneuver and provides the initial heading to be taken (e.g., north, south, east, west, northwest, etc.) The context information 350(3) may also include a field for "relative to" 350(3)(4). The "relative to" field 350(3)(4) is meant to be used in a starting off maneuver. The "relative to" field 350(3)(4) gives an initial intersection to be traveled toward. It can also be used in cases where the exit segment is unnamed (e.g., "turn right after Main Street"). The context information 350(3) may also include a field for "number of exits" 350(3)(6) which can be used for roundabout maneuvers. This "number of exits" field 350(3)(6) includes the number of exits to be passed traveling along a roundabout before reaching the desired exit.

In addition to the members mentioned above, the maneuver data structure 350 may include additional members 350(5).

1 The maneuver data structure also includes information for providing advisories.
 2 Advisories are types of useful explication information that are not necessarily associated
 3 with a maneuver. Advisories may be provided when there is a change in the road
 4 network, but a specific driving maneuver is not required. For example an advisory may
 5 be provided when entering or leaving a bridge or a tunnel. The maneuver data structure
 6 350 includes a field that includes a listing 350(4)(3) of one or more advisory types.
 7 Referring again to Figure 5, in addition to the maneuver rules 332 which are used for
 8 determining whether to explicate a maneuver at a particular node and forming the data
 9 structures 350 therewith, the maneuver configuration object 330 also includes advisory
 10 rules 370. The advisory rules 370 are applied to each of the nodes in the route calculation
 11 object 342. Like the maneuver rules 332, the advisory rules 370 are in the form of a table
 12 372. The advisory rules table 372 includes a set of advisory types 376 and a set of
 13 advisory condition tests 378. Each advisory type 376 characterizes a particular kind of
 14 advisory that can be provided at a node. Each advisory type 376 is assigned a unique
 15 code or number. Each of the advisory condition tests 378 is formulated so as to permit
 16 only positive and negative results. A unique subset of the advisory condition tests 378 is
 17 associated with each different advisory type 376. If positive results are obtained for all
 18 the advisory condition tests associated with an advisory type 376, that advisory type 376
 19 is associated with the maneuver at that location.

20 Unlike the rules for maneuvers, the rules for advisories do not require a unique
 21 result. Thus, for a given location along a route, there may be one advisory type, multiple
 22 advisory types, or no advisory type. The number or code for each advisory type 376 is
 23 included in the data structure 350 formed for that location.

24 The application of the advisory rules is independent of the application of the
 25 maneuver rules. Thus, application of the advisory rules can require that an advisory
 26 instruction be provided at a location along a route even if the application of the maneuver
 27 rules at the same location does not require that a maneuvering instruction be provided. If
 28 application of the advisory rules requires that an advisory instruction be provided at a
 29 location, but application of the maneuver rules at the same location does not require that a
 30 maneuvering instruction be provided, a maneuver data structure is formed for that
 31 location containing data for the members of the data structure to the extent the data are

1 available. A maneuver data structure formed for such a location would have a maneuver
2 type of "0."

3 The maneuver generation configuration object 340 traverses the list 344 of data
4 entities in the route calculation object 342 so that each node along the calculated route is
5 tested with the maneuver rules 332. A maneuver data structure 350 having information
6 for each of the fields identified above (to the extent such information is available) is
7 formed for each location in the calculated route at which the all the maneuver condition
8 tests for any of the maneuver types or all the advisory condition tests for any of the
9 advisory types are satisfied. The maneuver data structures 350 formed by this process are
10 contained in order in the maneuver generation object 340.

11 Referring again to Figure 3, the maneuver generation object 340 is provided to a
12 builder application 400. The builder application 400 is included on the navigation-related
13 information server 200. The builder application 400 takes the maneuver generation
14 object 340 provided from the maneuver generation application 320, extracts the
15 information from the maneuver generation object 340, forms a language- and format
16 independent data structure 420 that contains the information from the maneuver
17 generation object 340 and outputs the language- and format independent data structure
18 420. In the embodiment of Figure 3, the builder application 400 is an XML (eXtensible
19 Markup Language) builder class and the language- and format independent data structure
20 420 is an XML string. The language- and format independent data structure 420 is
21 distributed in at least two ways. These two ways include saving the generated string 420
22 into a file or sending the generated string 420 to its caller, i.e., the customer-interface
23 server 202.

24 In one embodiment the builder application 400 is implemented using C++. In this
25 embodiment, the builder application 400 includes an XML generator 440. The XML
26 generator 440 takes the maneuver generation object 340 and creates the string 420. The
27 string 420 contains the XML representation of the maneuver object 340 that is passed to
28 the communications system 266 for transmission to the customer-interface provider 220.

29 The following example shows the contents the XML structure. These element
30 names would be referenced in the XML Stylesheet used by the customer-interface
31 provider.

Example

```

<Direction>
  <Source>1975 ORCHARD ST, DES PLAINES IL</Source>
  <Destination>1368 N WESTERN AVE, PARK RIDGE IL</Destination>
  <Maneuver id="1">
    <ManeuverType>0</ManeuverType>
    <Advisory>
      <Type>7</Type>
    </Advisory>
    <Node>
      <ExitSegmentInfo>
        <SegmentName>ORCHARD ST</SegmentName>
        <NameChangedFlag>1</NameChangedFlag>
      </ExitSegmentInfo>
      <GeoPosition>
        <Latitude>4201745</Latitude>
        <Longitude>-8788161</Longitude>
      </GeoPosition>
    </Node>
    <Context>
      <ExitHeading>NORTH</ExitHeading>
    </Context>
    <DistToNextManeuver Units="Meters">756</DistToNextManeuver>
    <DistFromOrigin Units="Meters">0</DistFromOrigin>
    <TimeToNextManeuver>131</TimeToNextManeuver>
    <TimeFromOrigin>0</TimeFromOrigin>
  </Maneuver>
  <Maneuver id="2">
    <ManeuverType>6</ManeuverType>
    <Node>
      <EntrySegmentInfo>
        <SegmentName>ORCHARD ST</SegmentName>
        <NameChangedFlag>0</NameChangedFlag>
      </EntrySegmentInfo>
      <ExitSegmentInfo>
        <SegmentName>E OAKTON ST</SegmentName>
        <NameChangedFlag>1</NameChangedFlag>
      </ExitSegmentInfo>
      <GeoPosition>
        <Latitude>4202426</Latitude>
        <Longitude>-8788203</Longitude>
      </GeoPosition>
    </Node>
    <Context>
      <DestinationText>E OAKTON ST</DestinationText>
    </Context>
  </Maneuver>
</Direction>

```

```

1         <TurnAngle>RIGHT</TurnAngle>
2         <ExitHeading>EAST</ExitHeading>
3     </Context>
4     <DistToNextManeuver Units="Meters">3038</DistToNextManeuver>
5     <DistFromOrigin Units="Meters">756</DistFromOrigin>
6     <TimeToNextManeuver>274</TimeToNextManeuver>
7     <TimeFromOrigin>131</TimeFromOrigin>
8 </Maneuver>
9 ...
10 <NumManeuver>4</NumManeuver>
11 </Direction>
12

```

13 IV. THE DATA CONVERSION APPLICATION 14 ON THE CUSTOMER-INTERFACE SERVER

15 Referring to Figure 2, the language- and format independent data structure 420 is
16 transmitted from the navigation-related information server 200 over the data network 140
17 to the customer-interface server 202(1). When the customer-interface server receives the
18 language- and format independent data structure 420, the data conversion application 240
19 extracts the maneuver data contained in the language- and format independent data
20 structure 420. The data conversion application 240 then develops maneuvering
21 instructions using the contents of the language- and format independent data structure
22 420. The maneuvering instructions are formed in a selected language of the end user that
23 requested the navigation-related information. In addition, when forming the maneuvering
24 instructions, the data conversion application 240 applies formatting to the instructions so
25 that the instructions are provided on the requesting end user's computing platform.

26 If the language- and format independent data structure 420 that the data
27 conversion application 240 receives from the navigation-related information server 200 is
28 in the XML format, the data conversion application 240 may use XML style sheets 460.
29 The style sheets 460 conform to the XML format used by the builder application 400.

30 In one embodiment, the data conversion application 240 provides the
31 maneuvering instructions to the end user's computing platform in HTML format. The
32 data conversion application 240 includes a style sheet for this purpose. According to this
33 embodiment, the HTML style sheets used by the data conversion application 240 uses the
34 XML data 420 provided from the navigation-related information server 200 and
35 generates an HTML data file that contains the maneuvering instructions in HTML

1 format. The HTML data file is then sent via the data network 140 to the end user's
2 computing platform 130 where the HTML data file can be used to present the
3 maneuvering instructions to the end user using any application that can handle HTML,
4 such as an Internet browser.

6 V. ADVANTAGES

7 Several advantages follow from embodiments of the disclosed navigation
8 systems. The navigation systems allow end users that have different types of computing
9 platforms to obtain navigation services. The navigation systems also allow end users to
10 receive support in different languages. The disclosed embodiments achieve these
11 advantages by separating the functions of providing navigation-related information from
12 the customer-specific issues, such as specific language support and specific format
13 support.

14
15 It is intended that the foregoing detailed description be regarded as illustrative
16 rather than limiting and that it is understood that the following claims including all
17 equivalents are intended to define the scope of the invention.